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ABSTRACT

This paper reports on a part of a study of factors that contribute to science anxiety and science teaching self-efficacy among preservice primary and early childhood teachers. The experience and beliefs of primary and early childhood preservice teachers at an Australian University were explored in an ethnographic research tradition. In all, 366 students from four cohorts were studied. Two of the cohorts were undertaking a content oriented Science Foundations course that focused on matter and energy concepts. A third cohort undertook a Science Curriculum course that concentrated on science teaching methods, and the fourth cohort represented a smaller group of post-baccalaureate students who completed a combined content-methods course. The salient outcomes revealed that personal science teaching self-efficacy was associated with negative high school experiences and could be improved in situations where individual students experienced support and an appropriate learning environment. Outcome expectancy also could be improved through experiences in which students successfully implemented teaching programs to children. Analysis of qualitative data revealed interesting contrasts between students. A series of assertions about the causative factors that may influence the development of students' sense of self-efficacy were derived from an analysis of the data. Contains 46 references. (Author/LZ)

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Origins of, and changes in preservice teachers' science teaching self efficacy

by

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ABSTRACT

This paper reports on a part of a study of factors that contribute to science anxiety and science teaching self efficacy among preservice primary and early childhood teachers. It draws upon our experiences over four years with preservice primary and early childhood teachers at an Australian University. Primary teachers are responsible for the inclusion of science instruction in years 1-7 while the early childhood teachers should provide science experiences for children in child care, kindergarten, preschool and the early years of primary school. Science anxiety presumably develops through negative and limited experiences and impacts on people's interests and beliefs about science and, for preservice teachers, their confidence to teach science. Preservice training of teachers is an opportunity to provide positive experiences that may enhance student teachers' beliefs that they may become effective science teachers. Thus, the experiences and beliefs of primary and early childhood preservice teachers were explored in an ethnographic research tradition. In all 366 students from four cohorts were studied. Two of these cohorts were undertaking a content oriented Science Foundations course that focused on matter and energy concepts. A third cohort undertook a Science Curriculum course that concentrated on science teaching methods and the fourth cohort represented a smaller group of post-baccalaureate students who completed a combined content-methods course. Students' self efficacy, attitudes to science, perceptions of their University learning environment were measured at the commencement and conclusion of the semester of study and selected students were interviewed at various stages of the one semester course. The salient outcomes revealed that personal science teaching self efficacy was associated with negative high school experiences and could be improved in situations where individual students experienced support and an appropriate learning environment. Outcome expectancy also could be improved through experiences in which students successfully implemented teaching programs to children. Analysis of qualitative data revealed interesting contrasts between students. A series of assertions about the causative factors that may influence the development of students' sense of self efficacy were derived from an analysis of the data.

INTRODUCTION

In a wide ranging review of the status of science teaching in Australia it was emphasized that there is a need to enhance the discipline knowledge of elementary preservice teachers by increasing the number of hours of preservice training that should be allocated to content oriented courses (Department of Education, Employment and Training, 1989). However, the implementation of such a recommendation needs to be considered cautiously as it fails to account for the research on preservice students' attitudes towards science and science teaching much of which identifies the cyclical nature of 'success following success and failure following failure' (Lucas & Dooley, 1982; Ginns & Foster, 1983; Koballa & Crawley, 1985; Morrisey, 1981; Schibeci, 1984; Fraser, Tobin, & Lacy, 1984). As elementary preservice teachers as a group of students tend to have inappropriate understandings of science and appear to have little interest in teaching science (Ginns & Watters, 1995; Tilgner, 1990) research addressing the relationship between students' beliefs, attitudes and practice is essential to clarify the most effective strategies for implementing change.

The way a person performs or behaves in a given situation depends on attitudes which are manifestations of both cognitive and affective attributes of that person (Bandura, 1977; Ajzen, 1985; Prawat, 1985; Shrigley, Koballa, & Simpson, 1988; Hewson & Hewson, 1989). The extent to which teachers will teach science in elementary school, is influenced by the teachers' knowledge of science and the issues in teaching science as well as their feelings or attitudes towards those cognitions (Morrisey, 1981). These attitudes may

develop during their own schooling but may also be influenced by their preservice training experiences. For example, Germann (1988) postulated that students' fatalism, their perceptions of the value of science, teacher quality and classroom social environment and organisation appeared to be of significance in determining attitudes. Others have explored the relationship between the teaching of science and the student's perception of science (and technology) (Hewson & Hewson, 1989; Rubba & Harkness, 1993), the role of conceptual knowledge (Tilgner, 1990; Franz & Enochs, 1982) and "perspectives towards teaching" (Zeichner, Tabachnik, & Densmore, 1987).

One productive line of research into understanding teachers' abilities to cope in a potentially stressful situation has drawn upon social behavior research. A major construct emerging from this research is self efficacy (Bandura, 1977). Self efficacy is a situation specific determinant of behavior, and not a global personality trait, hence a teacher's self efficacy may be dependent on the particular teaching situation, in this case the teaching of science. Research on science teaching self efficacy has been facilitated by the development of a Science Teaching Efficacy Belief Instrument (STEBI-B) comprising two scales representing a personal self efficacy belief scale (PSTE) and an outcome expectancy scale (STOE) (Enochs & Riggs, 1990).

Changing self efficacy beliefs.

Successful performance, vicarious experience, verbal persuasion and emotional arousal have been identified as key contributors to the development of self efficacy (Bandura, 1977). In the context of preservice teacher education a number of studies have implicated the role of institutions (Stefanich & Kelsey, 1989) and courses (Duschl, 1980; Lucas & Dooley, 1982) as contributors to the development of attitudes. Gorrell and Capron (1988) argued that preservice training programs must attempt to "instill appropriate skills and attitudes" in prospective teachers and especially to focus on efficacy beliefs. They attempted to demonstrate that preservice students of high personal self efficacy levels would perform better than low self efficacy students in specific teaching activities involving teaching comprehension through observing cognitive modeling in which an instructor "thought aloud" during a teaching sequence (Gorrell & Capron, 1990). Such techniques did lead to improved performance by all students.

A previous study (Ginns, Watters, Tulip, & Lucas, in press) confirmed that personal science teaching self efficacy is correlated with a student's stated preference to, or not to teach science. Therefore, apprehension about science is already established at an early stage in students' preservice careers, thus providing further support for the need to explore the contextual factors that influence student teachers' beliefs about science and science teaching. A fruitful approach might be to follow Bandura's argument that performance is the major predicator of self efficacy which implies that students who experience successful learning will have positive self efficacy. From a constructivist epistemology, successful learning occurs in a social and emotional context in which knowledge is constructed cooperatively by learners (Pintrich, Marx, & Boyle, 1993). To what extent have preservice teachers experienced such contexts and do their university experiences provide these contexts?

Motivational theory may also inform our understanding of students' stated intentions to teach science (Kuhl, 1985; Ajzen, 1985; Locke & Latham, 1990; Menec & Schonwetter, 1994). Volition or action control, as conceptualized by Kuhl, invokes the notion that people deliberately apply strategies to ensure that personal goals are met. Furthermore the ability to enact intentions, according to Locke and Latham (1990), depends on such factors as their beliefs about what they can achieve, their recollections of past performance and their beliefs about consequences of their actions. It could be hypothesized that action oriented individuals would have greater control over self-efficacious beliefs and be more likely to engage in learning experiences that represent successful performance. Goal setting involving the implementation of learning strategies with feedback has been found to correlate with achievement and self efficacy (Schunk & Swartz, 1993). In essence what constitutes a successful experience for one person and hence provides the basis for change in self efficacy may depend on cognitive factors such as volition and self-regulation of action. The role of motivation in facilitating conceptual change has been highlighted by Pintrich, Marx and Boyle (1993).

To answer these questions changes in preservice teachers' sense of science teaching self efficacy have been explored with several groups of students preparing to become primary or early childhood teachers. The study involved monitoring self efficacy in students during their study of specific courses, namely Science Foundations and Science Curriculum, or in the case of a cohort of post-baccalaureate students a combined content-methods course. In order to probe the possible effect of contextual factors in self efficacy, attitudes to science were also measured using a variety of test instruments. Quantitative techniques were employed to identify factors which may reveal broad and generalized elements contributing to personal science teaching self efficacy and outcome expectancies. However, to understand individual differences it is necessary to explore interesting cases to develop more sophisticated descriptions and more powerful explanations of preservice elementary science experiences that may influence self efficacy. This paper will focus on reporting the richer qualitative data arising out of the interviews. Some of the quantitative data have been published elsewhere (Watters & Ginns, 1994a, 1994b; Ginns & Watters, 1994).

Thus, the objectives of this research were to:

- examine changes in self efficacy beliefs and attitudes to science during preservice training courses and,
- explore contextual factors through students' recollections of the critical incidents that may have influenced their self efficacy towards science teaching both before and during preservice training;

Background

Context. Annual enrollments in each of the preservice elementary or early childhood programs at the institution where this study was conducted are of the order of 150-180

students. The structure of science courses in the programs involves students attending a large group lecture of one hour and a two hour practical workshop in smaller groups of 25. The students are taught a content-oriented Science Foundations course in their first semester and a Science Curriculum course in their second (Bachelor of Teaching program) or fifth semester (Bachelor of Education program). The courses are taught by a number of instructors but the same instructors who teach the Science Foundations course are involved in the Science Curriculum course. A post-baccalaureate program (Graduate Diploma in Education) is offered that enrolls approximately 30 students who are presented with a three hour workshop course focusing on combined content and methods in mathematics and science conducted over two semesters by the same instructor who was one of the researchers (ISG). Synopses of the course work are are included in Appendix 1.

The study commenced in February 1992 with the freshmen cohort of Bachelor of Teaching students (Lucas, Ginns, Tulip, & Watters, 1993). Figure 1 provides an overview of the research and the times at which various cohorts were tested with the STEBI-B and other test instruments.

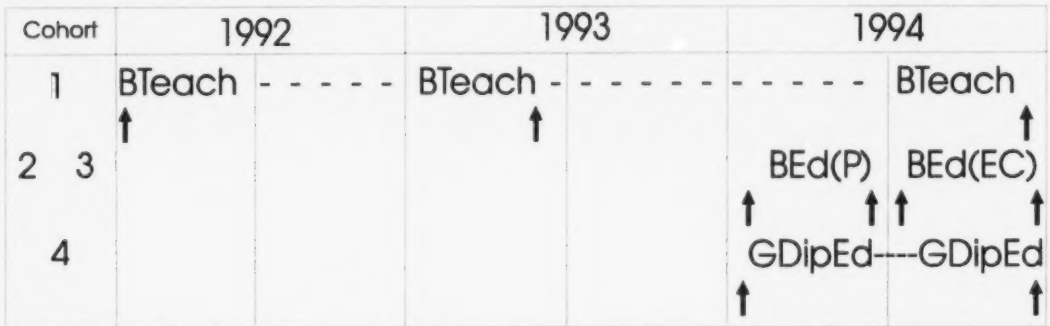

Figure 1. Cohorts studied and times of testing of Self efficacy (↑). Cohorts 1, 2 and 3 studied Science Foundations in their first semester. Cohort 1 studied Science Curriculum in Semester 1 1993. Cohort 4 studied a combined content/methods course. BTeach: Bachelor of Teaching 3 years; BEd(P): Bachelor of Education (Primary strand-4yr); BEd(EC): Bachelor of Education (Early Childhood strand-4yr); GDipEd (Graduate Diploma in Education-1yr.)

Three factors, the teaching environment, attitudes to science, and motivation were considered as potential contributors to the experiences underpinning the observed changes in self efficacy. These factors were explored quantitatively by administration of appropriate test instruments.

The Constructivist Learning Environment Scale (CLES), developed by Taylor, Fraser and White (1994) to examine the socio-cultural forces shaping the high school science classroom from a critical theory perspective was used to explore the learning environment within the courses. Factors identified as important elements of such an environment include: (a) making science seem personally relevant to the outside world; (b) engaging students in reflective negotiations with each other; (c) instructors inviting students to share control of the design, management, and evaluation of their learning; (d) students being empowered to express critical concern about the quality of teaching and learning activities; and (e) students experiencing the uncertain nature of scientific knowledge. An attitude scale is also a dimension of the instrument.

A measure of science related attitudes - Test of Science Related Attitudes (TOSRA) (Fraser, 1981) - was also administered to the BEd cohorts as a pretest in the case of the BEd(EC) group and as a pretest and posttest for the BEd(P) group. TOSRA measures issues such as students' perceptions of the social implications of science, their view of scientists, their appreciation of scientific inquiry, and interest in and enjoyment of science. The differences in these two instruments relates to specific versus global perceptions of attitudes. The CLES reflects on the immediate intervention and learning experience. The TOSRA considers established beliefs and attitudes.

The BEd(EC) cohort also completed the Action-Control Scale of Kuhl (1985) at the conclusion of the semester course. The action control scale comprises three subscales: performance-related action vs. state orientation, failure-related action vs. state orientation, and decision-related action vs state orientation. The action control scale purports to measure motivation and goal setting.

Results of the administration of these quantitative measures will not be reported in detail in this paper but results will be drawn upon to illustrate the direction the qualitative research followed.

METHODS

The design of this study was a combination of qualitative and quantitative approaches within an ethnographic research tradition. Self efficacy theory has provided the framework for understanding behavior but consistent with an interpretive research paradigm hypotheses have been generated that provide greater insight into the patterns and interrelationships in which self efficacy theory is embedded. Quantitative data have been obtained through a series of survey instruments while rich descriptions of individual participants have been acquired through interview, field notes and observation. The data are interpreted and synthesized as a series of vignettes of case studies to exemplify generalizable assertions.

Subjects

The subjects were drawn from four cohorts of students enrolled at an Australian University over three years. During the period of the study, preservice teacher education changed from a three year program leading to a Bachelor of Teaching to a four year Bachelor of Education program. Thus the first cohort were three year Bachelor of Teaching students undertaking a science foundations course in the first year of their preservice program. The second cohort comprised students commencing year one of a four year elementary teacher education program (Bachelor of Education (Primary)). The third cohort were students commencing a four year Bachelor of Education (Early childhood) program and the fourth group were post-baccalaureate students completing a combined mathematics-science discipline and methods course as part of a Graduate Diploma in Education (GradDipEd).

Procedures

Quantitative measures. At the beginning of their respective courses each cohort of students was presented with the STEBI-B instrument (Enochs & Riggs, 1990) and a range of other instruments described above during a scheduled workshop session. At the completion of the semester all students were posttested using the same forms of the tests. Selected students were also interviewed before, during and after the end of the course.

The STEBI-B has been validated for use within the context and for the level of students being investigated in this (Ginns, Watters, Tulip & Lucas, in press).

Qualitative data. The quantitative measures were complemented by a series of interviews of students in Cohorts 1, 2 and 3. Interviews were semi-structured and were undertaken in the second week of semester, in the last week of semester outside scheduled class times or in the case of the BEd(EC) cohort, at the beginning of the following semester. The interviews were designed to encourage students to focus on critical incidents in their lives that related to their learning of science either at school in the case of the first interview and during the semester in the case of the second interview. Several research assistants were used to record interviews but both pre- and post-interviews were conducted where practicable by the same research assistant. Each interviewer had completed a group training and briefing session. Codings of interviews were undertaken by two members of the research group and discrepancies reconciled by discussion. The outcomes of early interviews guided the direction and structure of subsequent interviews and also influenced the implementation of various quantitative measures. Some BTeach students provided reflective autobiographies of their school and university experiences in narrative genre (Connelly & Clandinin, 1990). In essence, emerging understandings and interpretations of the situation were tested through hermeneutic cycles of interview and survey implemented on successive cohorts (Guba & Lincoln, 1989).

RESULTS

Changes in mean Personal science teaching self efficacy (PSTE) and Science teaching outcome expectancy (STOE) scores for all four cohorts are shown in Table 1.

Table 1
Mean, standard deviation and paired samples t-test statistics for PSTE and STOE scores on four cohorts

Cohort	*n*	Mean PrePSTE (Std Dev)	Mean PostPSTE (Std Dev)	*t*- value	Mean PreSTOE (Std Dev)	Mean PostSTOE (Std Dev)	*t*- value
BTeach	72	45.08 (4.95)	46.11 (6.42)	-1.24	33.50 (4.2)	34.91 (5.14)	-2.11*
BEd (Primary)	108	44.84 (6.46)	45.85 (7.10)	-1.6	35.23 (3.68)	34.40 (4.18)	2.2*
BEd (Early Childhood	103	43.20 (7.12)	44.14 (13.75)	-1.23	33.65 (4.72)	33.76 (8.31)	-.25
GradDipEd	27	48.11 (5.53)	54.63 (5.69)	-7.03*	36.19 (3.1)	36.52 (3.33)	-.48

Note; * $p < .05$. BTeach results are for measurements made in 1992 and 1993.

The data for the BTeach cohort have been reported previously (Lucas et al., 1993). These students experienced both a content and a methods course as well as units of learning theory, sociology of education and other curriculum areas. The results suggested that the preservice program did not provide appropriate experiences to engender feelings of success and self confidence prerequisite to changing self efficacy. Attempts to examine the impact of further preservice training and the role of practical teaching experience in the second half of their program were thwarted by changes in the structure of the program. The changes allowed a large number of students to transfer to a 4-year Bachelor of Education program and hence these students were unavailable for testing. Only 11 students remaining in the Bachelor of Teaching program in 1994 were available for whom previous data had been collected. The means of the remaining BTeach students were 49.50 (PSTE) and 34.06 (STOE). Although these means scores increased between 1993 and 1994 the increases were not statistically significant.

As shown in Table 1 we observed that no statistically significant change in the PSTE scale with any of the undergraduate student groups. STOE however increased with the BTeach students who had studied the Science Curriculum course at the time of testing and decreased with the Bachelor of Education (Primary) students after their foundation course. In contrast, the Graduate Diploma students who underwent a combined methods and content course under a single instructor exhibited a substantial increase in mean PSTE scores. No changes were observed for the BEd(EC) cohort. Thus, content courses did not impact on personal science teaching self efficacy (PSTE) but may impact negatively on outcome expectancy (STOE). In contrast, outcome expectancy may be enhanced by

experience in science curriculum courses or through practical experiences in teaching science. This possibility needed further exploration.

The correlations between STEBI scores and CLES scales for the BEd(EC) and BEd(P) cohort suggested that issues concerning the personal relevance of science, the level of autonomy in the classroom and the enjoyment of individual activities were significantly related to PSTE. In contrast STOE scores were weakly correlated with a measure of the support for critical discussion of course content for the BEd(EC) cohort but correlated with all the scales for the BEd(P) cohort. Changes in PSTE for the BEd(P) cohort were only correlated with attitude scale. The quantitative data had revealed that there were differences between the two cohorts.

These results support the interpretation that the BEd(EC) cohort were perceptive of greater autonomy and may therefore have developed a greater sense of success in their experiences with science leading to higher self efficacy. Given that both groups received the same treatment, verified by independent observation, field notes, interviews with tutors and student work, it is reasonable to conclude that other factors are interacting to produce the different effects. The two cohorts of students are different in at least three ways. The entrance requirements into the BEd(EC) program are more stringent and places are more competitive favoring higher achieving students, secondly there is less expectation among BEd(EC) students of the need to teach science at least as a identifiable area of study. Indeed the BEd(EC) cohort are not required to undertake any further study, for example, a science curriculum course, as a compulsory component of their program. Thus the expectations of the need to teach science and the motivation to learn science themselves may be quite different for these two groups. Thirdly the BEd(EC) cohort were in the second semester of study, a factor that may indicate that they were less apprehensive about University life and had adapted to tertiary studies.

The relationship between self efficacy and attitude to science was also evident from the TOSRA measurements. The interventions had no effect on attitudes paralleling the observations for PSTE.

Analysis of qualitative data.

In all some 60 students were interviewed in this study. Students were selected either on the basis of extreme scores on PSTE or STOE at the commencement of the unit of study or if large changes were noted during the course. Where available those students selected at the commencement of the semester were also reinterviewed at the end of the semester. A selection of cases from three cohorts: BEd (Primary), BEd (Early Childhood) and BTeach will be discussed as exemplars (Table 2).

Table 2
Selection of individual subjects changes in PSTE and STOE scores and final subject grade for students intensively interviewed.

Subject		PrePSTE	PostPSTE	PreSTOES	PostSTOES	GRADE*
Kirsten	EC	32	44	34	38	5
DebraWe	EC	33	22	37	34	7
Anna	EC	37	49	45	35	6
Lesley	P	31	53	42	45	5
Lyn	EC	40	43	32	38	5
Michelle	P	42	51	38	41	4
Kerri	BTP	41	49	32	43	7
Fiona	EC	42	51	35	36	7
Cameron	P	43	51	33	36	4
Danya	EC	44	27	34	34	3
Melissa	EC	45	63	36	30	5
Adele	P	52	46	38	39	4
Debra-Wa	EC	55	46	35	23	4

* Grade range 1-7 with 7 maximum.

During the post interviews, students' reflections on the workshops were probed in a semi-structured format. Interpretation of the interviews are presented and discussed as a series of assertions. Before exploring the assertions the impressions left by one BEd(EC) student whose self efficacy improved on both scales are worth recording. Kirsten, although not highly successful in grade scores did value the experience and responded positively. When questioned about the substantial change in PSTE and STOE scores she identified a confidence with knowledge of content. At the beginning of the semester she recognized a deficit in content knowledge. By the end of the semester she was more confident of her knowledge.

> It's just I think it's the time since I've even learnt science, like year 10 to now. So I was thinking: science I haven't done that for so long. ... Now I've like done it I feel better about teaching it rather than having to use my knowledge from year 10 which I didn't remember at all to teach like children that are depending on me.

With respect to outcome expectancy, she referred to broader issues of good teaching.

> Teachers if they teach good then the children can like understand better and it all depends on how the teacher teaches I think

Indeed Kirsten provides a case in which a number of assertions which relate to enhanced self efficacy can be postulated.

Assertion 1: *Experiences in school are related to low or high self efficacy.*
The most powerful recollection held by students and expressed during their first interview concerned the quality of teaching at high school. Comments by students who had PSTE scores in excess of 50 all reflected well on teachers. The role of teachers at school, especially, was highlighted by a number of the students as having a strong impact on their interest in science. "Teachers need to make the subject exciting." Although primary school

was seen in a positive light, secondary experiences were frequently negative. Kirsten's recollections of secondary school reflect an all too common image of didactic teaching.

I: Did your attitude change when you got to senior school?

S: I just hated going to all the, all the lessons we had, we'd just sit there and the teacher would just stand there and copy off, you know write you know, big board full of notes and then he'd rub them off and then he'd write them up again, and you'd just sit there. That's what it was the whole time and that's why I sort of, I think, I didn't like it because it was just copying down, copying down. Every lesson you'd just go and copy down or get lecture, ah notes and you'd..

I: So what is it about copying down that you don't like? Can you explain it more?

S: Just not doing things. Just not doing. I'd rather have hands on and doing experiments. I know some of things you have to have notes for but I'd rather do the things and find out for myself and rather then just sit there and copy, copy, like every time it was. Like when we'd do an experiment, all right all right, otherwise we'd be (exasperated motion)

S: When I found out I was going to do science this semester it was like, oh no. And I heard from a few people last semester that it was pretty boring and that sort of thing and I just went oh no.

I: So you had a really negative attitude about it?

S: Yeah.

Other students shared these experiences. For example, Anna, who also experienced substantial gains in her PSTE score, reflected negatively on her school science experiences concerning the teaching and assessment of science:

> They (science teachers) were all terrible terrible, in that they spoke in a monotonous tone for the whole period of they were in front of the class teaching. There was no one to one interaction. The teacher was basically the sender, I don't know how to put it, just basically gave us all the knowledge that we were supposed to have in order to pass at the end of the semester. And assessment was always the same, exams at the end of the semester which placed a lot of pressure because you had to learn all of that semesters work in order to pass. You know there could have been a number of ways we could have been assessed.

Finally, Cameron a preservice BEd(P) teacher whose personal science teaching self efficacy increased by 8 points reflected on his previous experiences to do with science at the commencement of the course.

> In years 11 and 12 I studied biology which I preferred to other sciences I had studied in year 10 because they got too complex. In particular, my year 10 teachers were bad. The teacher just pumped the facts out to us and I could not get an understanding of Chemistry or Physics as it just went straight over my

> head. My mother is a nurse and she was supportive of me steering me towards biology.

His reflections were typical of many students who were interviewed in this study. The difficulties and lack of interest in science was attributed to a negative experience during the early years of high school. Family support and encouragement were significant in influencing this student to pursue biology. At the completion of the semester his experiences are reconstructed in the following narrative.

> At the commencement of semester I was quite apprehensive about this subject. My previous experiences with chemistry and physics were unfortunate. Nevertheless, I began with a feeling that science could be fun because it is easier to understand at a lower level and we won't go into as much complexity as in high school. I think I could teach it well but I believe that children can only learn science up to a point. I am now a lot less concerned about learning science because I found that the lectures were good and in particular the teaching staff seemed all right as people. The workshops and lectures were good, because the lectures were related directly to the workshops.

The identification of *science being fun* as a important contributor to enhancing confidence leads to the next assertion.

Assertion 2: *Science experiences for positive self efficacy changes should be fun.*

Students who expressed a positive attitude to science linked their feelings to interest in activities, excitement and practical or hands-on work. A minority spoke in terms of a quest for knowledge and a need to understand science for social ramifications. The predominant reasons for not liking science related to modes of learning including too much writing, no discussion, too theoretical, boring and irrelevant content material. Strong correlation between both career and leisure interest in science with PSTE are consistently seen in all groups.

Blumenfeld-Jones (1994) asserts that pleasure may be a central category of belief to which educational beliefs may be connected. Students in the laboratory sessions had the opportunity for public discovery and exploration of concepts and sharing those discoveries with peers in a "marketplace of ideas" or a "community of learners" (Brown, 1994). Several students described experiences that they framed in a context of fun. For example, the BEd(P) preservice teacher Michelle considered whole group lectures as boring but laboratory experiences in workshops were fun and motivating: "Lectures were boring but my views changed when I went into the group. Laboratory was great fun and it made you interested. If you are not interested in the subject you won't listen". Adele shared similar impressions. In her first interview, she expressed sentiments that have been observed in the majority of preservice teachers interviewed for this study.

> Science to me is learning things in parrot fashion. It's all about writing things out and trying to remember them. That is a bad way of thinking but it is what happened at high school where we were told to do that as the only way of getting through. I wish there was another way and that you could enjoy science

> and understand science without writing hundreds of times. I really hate sitting at home trying to learn something by heart.

The BEd(EC) student Kirsten, once again, provides support for this assertion when probed about interest in teaching science:

> Early childhood yeah, because it's most, well I think its mostly experiments. You don't, like I don't remember anything like them writing up on the board, like you hardly even know how to write or read or anything so you don't stuff like that. They mostly do fun experiments so, and I think they can be really, not excitable, I'm not sure excited is the word but I could like find interest in doing that like teaching kids that. That's what I remember doing. That's what I like doing.

Contributing to fun and interest was the opportunity of discussing ideas together. In keeping with constructivist views of an effective learning environment the opportunity for discussion of one's own ideas is important for effective learning.

Assertion 3: *Opportunity for discussion and interaction promoted the maintenance or improvement of self efficacy and provided an environment where risk taking was encouraged.*

Some students with low PSTE scores indicated an attitude towards science which is dominated by fear but also a desire to overcome that fear. They suggested that they would not be competent at teaching science because they do not understand the content but they have a volition to understand science. These students wanted to ask questions, but not feel foolish and to achieve this they sought opportunities to establish or select workshop environments that were more informal and where the possibility for discussion and negotiation of meaning between students themselves and tutors existed and was practiced.

> I'm more the sort of person that listens to other people and then makes my own judgments like in my own head rather than saying. But I'm better at working like in little groups rather than like the whole sort of tute so when I was with my friends and that I'd say: 'oh why does that happen or I don't think so' but like in the bigger groups I'm not like..I don't put my hand up and answer questions

Michelle, a preservice BEd(P) teacher whose PSTE improved, highlighted the role of cooperative groups and discussion in reflection on the course.

> At university I found initially that lectures were boring but my views changed when I went into C's group. There you could say what you wanted to. Her group was not so formal and she encouraged us to present our own opinions. Laboratory was great fun but I did not always enjoy every experiment. It was the opportunity to discuss that was of benefit. As I said before, if you are not interested in the subject you won't listen. Also the structure of university lectures is not conducive to learning. People, like me, are too embarrassed to talk in front of 150 students. Nevertheless, lectures were still relevant. But I believe that it is hard to make things interesting especially with science.

Similar feelings were expressed by Lesley, a mature age student who made a point that underpinned her concern about science in her first interview and reinforced the same idea 14 weeks later. Before classes began she described her apprehension about science. This apprehension was also evident in a low PSTE score of 31.

> My reaction to science is a mixture between fear and a desire to overcome that fear. I want to ask questions, but not feel foolish. I don't feel competent at teaching science because I don't understand it. I have a desire to find out but I cannot learn things by rote, I must understand. I think I am the one who will lose out if I don't ask questions.

Subsequently, Lesley acknowledged her earlier anxiety, but was adamant that her feelings had changed because: "the workshops have changed my attitudes. Journal writings in the workshop helped ... I wanted to talk about science which we were able to do in tutorials". Lesley's PSTE score meanwhile increased from 31 to 53.

This condition however was not always accompanied by a positive change in PSTE. For example, Debra Wa although confident about contributing to group work and cooperative learning experienced a decrease in PSTE score.

> We were always able to express our ideas before we actually did the experiment. You know how we got those sheets of paper that told us what to do before we went off and did that they would stand up the front and the whole class would like have their ideas and we'd write them on board and they could be totally different experiments to what was on the paper and she'd let us find out what we wanted to know sort of thing so it wasn't so structured which was really good cause we could find out things that really interested us

Assertion 4: *Students are driven by internal and external motivation.*

Students who were of higher self efficacy often expressed concern that the most important task was to achieve well on the examination. Time consumed through discussion of their own knowledge in workshops that implemented a constructivist approach to learning was inefficient. These students were more comfortable in a learning environment in which didactic approaches were implemented. However, although such an environment allowed them to overcome their immediate concerns it did not enhance self efficacy.

Other students however, appeared to adopt more comprehensive personal goals. Again in the comments of Kirsten we find these self-regulatory features. She recognized that she would have to teach science and therefore master the course she was undertaking to achieve this goal. Strategies were deliberately developed and adhered to. Action control was an important contribution to study performance despite low levels of attitude. Kirsten indeed displayed a high generalized action orientation on all subscales of the Kuhl test.

> K: I tried to sort of look at when I started it as something like new not like..sort of forget my past experiences cause I thought well I've got to do science so you know I'm going to be teaching it so I've got to actually try and make it well make myself interested in it and try and actually learn something from it so I

just and I did like the journals every week trying to keep up to date and just try to just learn as much as I could cause I knew like at high school it was just like oh science won't be doing that again and then when I came here I thought oh God I'm actually going to need this for.. I'm going to teach kids and they're going to learn from me so if I don't know anything about it or just don't have any idea so I thought it's up to me if I want to learn about it. I'd have to teach it and I'd have to make it interesting for children and like from when someone says science to me I'm like no I don't really want to do that so I thought I'll have to make a conscious effort for like kid's sake anyway to like learn about it because if they ask I can't just say - oh I don't know so for them rather than really for myself.

I had something in mind why I was doing it this time and so that made it easier for me to sort of concentrate more. Like in high school there was no real point

I: Would you say your approach to study in that unit was similar to what you did at high school?

K: No, that was just like another subject it was sort of... I didn't like actually plan... it was just like last minute study, like cramming but this one I knew that I'd have to learn, I'd have to sort of get organised...

I: And you're quite happy with the idea of teaching science

K: I wouldn't say quite happy but I feel better now that I'm actually cause like last time I did it was Year 10. So it was good to like just have a refresher and just like understanding it.

The perception of relevance of the material being learnt was also important. The CLES instrument contains a measure of the extent to which the learning experience has been made explicitly relevant to the learner. Scores on this scale were strongly correlated with change in PSTE. The qualitative data support the importance of this factor.

Kirsten found relevance in the content of the course from a personal perspective but remained concerned that she still needed to understand how to teach the content.

K I mean it was relevant but not like directly... like it was relevant for my understanding but not as though I could teach this exactly to children. It was relevant just for my like if someone said to me oh what about this or why is that happened. I could maybe try and explain it well rather than but it just wasn't in like children's terms

I: Did that worry you

K: Sometimes like I was glad that I could understand it but then like I didn't know how I was going to get it from my head like in the words that I sort of was taught to the children like in ways that they'd understand

I: Given that what you were doing you may not have seen the relevance to teaching in classroom did you see any relevance in what you were doing to yourself, to your own life

I: Yeah, a few of the things were interesting. Actually, I really did it was quite interesting why the sky is blue I was actually fascinated I had no idea and all the light and that really you know quite got me and some of the things were interested like as a oh wow that's something just as a passing by but I didn't particularly want to learn it. As such you know it's interesting to know. Oh well the only thing I can think of at the moment why do some cars have that strip at the back it's to let the current go um I'd always looked at that and thought why is that there. So you know points like that were sort of interesting but some of the stuff like pressure and that I'm just doing well this is fun I didn't see any implication.

Some students, for example, Debra-Wa failed to find relevance in the course content. Her self efficacy decreased during the semester.

> Well I think the lab sessions were really good you know you got involved and stuff but lectures I was really struggling to find the relevance of how this related to early childhood things. Like I couldn't understand why we had to learn formulas and things and like for the exam we had to know formulas so we could put them into things I didn't understand how that was relevant so I kind of got myself worried about this maybe I'll have to do this when I'm a teacher. You know do I have to recite all these formulas and stuff that's what I just couldn't find the relevance of it

But finally Anna who experienced a substantial rise in PSTE, clearly had developed an increased interest and personal awareness in the role of science.

I: At the end of the unit would you summarize your feelings towards science

A: It's integral ... to any learning situation. It just overlaps so many areas I think and it combines maths and logic and general knowledge and sets out to explain the natural world and also the intangible phenomena in our world

I: And do you think the unit itself contributed to that change in belief

A: It did yeah

I: Cause I mean just emotionally do you believe if you had the opportunity would you do more science

A: Yeah I continued to read the physics textbooks after the end of the year

Assertion 5: *Science teaching outcome expectancy is enhanced through experiences with children.*

Overall no significant changes in STOE were observed during the Science Foundations course in any of the cohorts. Prior to undertaking methods courses students frequently expressed the idea that only "smart kids" can learn some science, for example, chemistry or physics. These ideas were tempered with notions that good teachers could have a significant impact on children learning science. There was a concern that teachers had to make science interesting. During the methods courses outcome expectancies significantly

rose. The identifiable contributing factor was that students had the opportunity to explore directly with children the learning of science and to become familiar with the necessary pedagogical content knowledge.

Kerri, a mature age Bachelor of Teaching student summarized her feelings in an interview conducted at the completion of her methods course and after a period of practical teaching in which she had implemented lessons developed in the course.

> When I started University, I knew that I would have to teach science because I have got a couple of children so I have got experience through their schooling. Nevertheless, I was very daunted by the prospect of teaching science and expected to find any way out of the situation if it arose.
>
> I now feel different. I did it in my last practice and it was really good. It was one of my better subjects. Kids are really interested in science these days. Personally, I loved it and really would like to extend it but I am not confident in my own ability. I wanted to do the extension electives[i] but chose easier subjects to get my GPA up.
>
> Kids can learn science because they are inquisitive about things. If you make science hands on and very basic and you can extend it for those kids who know a lot or plan for those who are at a lower level of intelligence. The teacher can give kids a lot of confidence through science. Since I started University I have realized the importance of teaching science. It gives kids with low self esteem more confidence. It is as important if not more important as mathematics and language which are subjects that they have to achieve at a certain level. If you are a good enough teacher you can make science a subject that kids will excel at. It can be interwoven into other subjects. It can be taught at levels appropriate to the kids you have got in your class.
>
> I saw the content subject irrelevant but the curriculum subject was very important in influencing my ideas. Science is important and I want to teach it.

CONCLUSIONS

This study showed that prior experiences related to the learning and teaching of science may influence beliefs about one's ability to teach science operationalized as Personal Science Teaching Self Efficacy. Some key findings include the role of preservice teachers' own recollections of their teachers as a factor in developing positive teaching self efficacy. Science related attitudes identified in terms of students beliefs about the social implications of science, normality of scientists, scientific inquiry and adoption of scientific attitudes did not feature predominantly in developing self efficacy although an awareness of the social implications of science contributed to changes in PSTE during content courses.

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[i] Students can elect to undertake a suite of three content-oriented subjects as a major in their preservice course.

PSTE was previously found to be related to an academic self concept measure described as *identification versus alienation* (Ginns et al., 1995). This scale is a measure of a student's feeling that teachers care about their students (Michael & Smith, 1976). Changes in PSTE were also correlated with elements suggested to be important in establishing a constructivist learning environment in particular the relevance of the material taught, having a critical voice, acknowledgment of the uncertainty of science and a general attitude to the science taught. However, there were no net gains in PSTE and hence one must conclude that other factors work to ameliorate the individual student's perceptions and interpretations of the workshop interventions. The qualitative data also suggested that the structure and implementation of university workshops that encouraged students to participate in discussion and to air their problems enhanced PSTE of students. However, this was not universal as some students expressed concern that they were not likely to be successful in examinations in that environment. Thus the goals set by students themselves are instrumental in whether changes in PSTE will occur. Some support for this assertion was evident in the interview data but was not supported by the quantitative measures involving Action-control theory.

Self efficacy theory is predicated on the hypothesis that successful experiences lead to a sense of being able to cope in a potentially stressful situation. This may be inconsistent with current analyses of motivation theory. The traditional view of motivation sees *motives-as-drives* through which internal needs or states impel individuals to action. The need for success or achievement has been seen as a balance between a desire to approach success and a fear of failure which results in a disposition to avoid situations that are threatening (Covington, 1993). The sense of being in personal control, of being able to attribute success to personal factors rather than external factors underpins noteworthy accomplishments. The meaning that individuals attribute to their successes and not "simply the frequency of their occurrence" may need to be considered in these circumstances. Furthermore, Covington argues that an alternative metaphor to explain motivation to act in a particular way is necessary. *Motives-as-goals* sees individuals drawn to action by incentives that reward. Intrinsic motivation where engagement in tasks involve achieving multiple goals that unfold as the task proceeds may be a powerful incentive. For undergraduate students, such tasks may involve the constructivist model of teaching and learning where negotiation and cooperative learning are mandatory. Courses which have been shown to involve eliciting intrinsic involvement have been built around opportunities for students to negotiate with instructors about the nature of course requirements (Garcia & Pintrich, 1991). The emerging implications clearly lie in defining what individual students perceive as success, and their reasons for task avoidance.

The science teaching outcome expectancy increases during experiences that involve children learning science. Observation of the successful impact of science teaching on children appears to be necessary. This assertion will be explored in ongoing research involving students teaching science in practical field experience programs in schools mentored by appropriate role models.

These results partially confirm the suggestions of Ashton and Webb (1986) that self efficacy may fluctuate during the course of a teacher education program perhaps varying as students experience difficulties or success with various facets of a preservice teacher education program. Factors contributing to changes in self efficacy are clearly complex and will be difficult to address in order to implement effective teaching programs. Unless adequate resourcing of preservice programs is imminent in order to deal with individual students and provide a variety of support mechanisms the implications for elementary teaching are pessimistic.

The findings affirm the conclusion that there is a need to monitor preservice teacher's sense of science teaching self efficacy and consequent development of attitudes to science and science teaching if only to identify students possibly at risk. These conclusions strengthen our conviction that it is also necessary to monitor the changes in self efficacy as teachers are inducted and socialized into the teaching profession. Furthermore, our results imply that planning and implementing effective courses requires consideration of how to make the content of these courses explicitly relevant, enjoyable and of intrinsic interest to meet the long term goals of student teachers.

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Appendix 1
Objectives and content of Foundations and Methods Courses

Science Foundation Unit

Objectives:

On completion of this unit students should be able to:

1. describe the nature of scientific endeavour and apply these principles to scientific investigation;

2. demonstrate knowledge and understanding of significant scientific concepts;

3. demonstrate high level thinking and problem solving skills in significant science concept areas;

4. critically discuss the nature of science, the historical development of science and the relationship of science to society;

5. use and understand appropriate scientific language and understand its relationship to general literacy.

Content:

The content is organised in the form of key ideas, or themes, which are considered throughout the semester. The key ideas are described below:

a. Principles of scientific investigation.
The basis of scientific endeavour and principles of scientific investigation will be investigated. For example, the scientific process skills will be critically analysed, in theory and practice, as a means of developing students' scientific reasoning.

b. Atomic theory, properties of matter; energy forms and energy transformations.
Fundamental concepts in the broad areas of matter and energy will be discussed. The structure of atoms and molecules will be probed in order to explain the nature and behavior of matter. Concepts related to energy forms, such as heat, light, electricity, and energy transformations will be investigated.

c. What is Science?
A thorough examination of the nature and role of science will be addressed not only within the context of the topics already examined but as a separate issue of epistemology and the philosophy of science.

d. Science and Society.
Paradigms for scientific investigation have played a significant role in society's view of the world. Each modification to these views has brought with it a revolutionary shift in the scientific view as well as the social view of the nature and role of humanity and the world in which we live. In addition, studies have been carried out examining the nature of the scientific community, the organisation of scientific knowledge and the role of science in the economic well being of a country. An examination of these issues will be used to emphasise the interrelatedness of knowledge and social concerns as well as the approach to the solution of major issues.

e. The literature of science.
The original writings of scientists and the publication of views on the implications of their findings will illuminate all the topics as well as providing insights into the language and literature of science.

Science Curriculum Unit

Objectives

On completion of this unit student should be able to:

1. analyse and describe the theoretical bases of science curriculum development;

2. demonstrate an understanding of the development of children's science concepts, reasoning abilities, manipulative skills, and attitudes;

3. articulate the components of and provide a rationale for any worthwhile science program;

4. demonstrate an ability to organise and use appropriate scientific materials and resources in various teaching environments;

5. prepare, implement and evaluate science learning experiences of short or extended duration, for children in a variety of settings.

Content

a. Bases of science curriculum design. It is assumed that students entering this unit will have a sound understanding of child development and learning. However, there are particular psychological, developmental and sociological approaches which have played a significant role in science curriculum design and development. The role of these various influences on curriculum development will be explored.

b. The essential elements of a science program. In this topic there will be an emphasis on developing an understanding of the particular process skills and manipulative skills associated with science. The concepts and content of science appropriate to programs for children will also be examined. Each of these attributes will be specifically analysed, as well as their relationships to each other.

c. Comparison of existing approaches to teaching science. Science learning takes place in a variety of ways and a variety of situations. Science educators have developed public programs such as in Science Centres. There are also alternative approaches in the schools such as Project Clubs. These will be examined for the insights they provide about learning.

d. Science development associated with mathematics and language development. The use of words, their meaning and construction will be examined in relation to the development and articulation of concepts. Similarly the relationship between mathematics and science will be examined in terms of the contribution of mathematical language, concept development and problem solving to children's learning and understanding of science.

e. Resources for science education. Science is highly dependent on appropriate resources and practical skills. These will be analysed, sources located and alternatives designed.

f. The culmination of the science education program will be the development and implementation of units of work. These will be based on the analysis of children's concepts, skills and attitudes.